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NOT USING SCIENTIFIC TERMINOLOGY? A STUDY THAT INVESTIGATES LANGUAGE AND CONCEPT DEVELOPMENT IN THE PRIMARY SCIENCE CLASSROOM

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Abstract: The language of science has the potential to aid high order conceptual explanation and provide an effective means of communication, but emphasis on verbal correctness can frequently limit children's ability to conceptualise scientific ideas. Furthermore as children are introduced to the discourse of science they may experience cultural insecurity, limiting identity with the subject and potentially resulting in underachievement. This qualitative study takes a socio-cultural perspective and investigates whether an approach that minimises the use of scientific terminology in the classroom can impact the learning of primary age children. The work was carried out in schools serving socially disadvantaged communities where the issue of cultural disaffiliation from the practices of science can be more significant. Planning meetings were carried out with teachers in which concepts were isolated from the scientific terms traditionally associated with them. The discourse of the teachers in these meetings and in follow up interviews was recorded, being supplemented by recordings from classroom observations. Data was analysed for evidence of identity with particular modes of discourse and the level of exploratory discourse that took place. This analysis has indicated that there was an increased focus on exploratory discourse in the classroom with enhanced confidence in explaining concepts using everyday language. Evidence was also seen of greater identity affiliation with the social discourse of science for both staff and pupils, particularly among less able boys and those with literacy difficulties. The study reveals the significance, for children at a formative stage in their education, of cultural identity with science's discursive practices and the importance of pedagogical approaches that focus on language and conceptual development.

Key words: discourse, identity, literacy, narrative, socio-constructivist

BACKGROUND

Research in science education has stressed the importance of fostering discursive practices in the classroom (Driver et al, 1994), so that children can start to appropriate the social language of science and construct their own meaning. Learning in science involves making the shift from having "informal knowledge" gained through experience to constructing "scientific conceptual knowledge" involving more abstract ideas. The literature highlights the key role of language in mediating this shift as it provides a structure for thinking and constructing understanding. (Mercer et al., 1995; Vygotsky, 1998). It is suggested that teachers and knowledgeable peers can

support knowledge construction through interaction with learners that employs scientific discourse. This gap can also be understood in terms of Bakhtin's notion of "alterity", where understanding of learners' conceptualisation is sought in relation to the formalised concepts of science (Wertsch, 2000). The teacher's role would be to assess this conceptual alterity and reduce the gap through social mediation.

There are a number of issues though with the socio-constructivist paradigm, not least the appropriation of the complex language associated with science. The precise, technical nature of the language presents problems for many children, not just those with specific literacy difficulties, but it is the perceived acceptability of only certain discourse modes that may cause more significant issues related to identity. Hence as children are introduced to the discourse of science they may experience cultural insecurity, limiting identity with the subject and potentially resulting in underachievement. Children have to learn to play the "game of science" in which language increasingly does not respond to experience, but rather describes conceptual constructs and has to do so in a particular way, a concept referred to by Bernstein (1990) as acculturation.

School science teachers have been shown to have a literacy approach that does not contextualise scientific language and may therefore exacerbate feelings of alienation that pupils are experiencing (Yore et al, 2004). The links between language and identity are well documented (Gee, 2001), though largely outside of the science education field, but it is evident that the science classroom can potentially present identity conflict for many children. Furthermore there is evidence that children from socially disadvantaged backgrounds are less likely to make a transition to using the formal language of science. (Lemke, 1990; Halliday and Martin, 1993). This language is, in Bernstein's notions on codes (1990), restricted and elaborated, and is more accessible to middle class children who have been acculturated into use of such elaborated codes within the home.

Rationale and Purpose

The English National Curriculum for Science has undergone significant revision in the past year in preparation for its first teaching in 2014. In part this is an attempt to halt England's increasingly poor performance in international comparison exercises, as illustrated by the recent OECD PISA results which showed that the country had now slipped to 21st place for science in 2012, compared to 4th place in 2000 (OECD, 2013). There is an increased emphasis placed on the development of scientific vocabulary in the 5-11 age range, as illustrated by the following excerpts:

Ensure pupils continue to practise the scientific vocabulary of forces (gravity, friction, air resistance). (DfE, 2012, P.31)

Pupils should read and spell scientific vocabulary correctly and with confidence, using their growing word reading and spelling knowledge. (DfE, 2013, P. 13)

There is an assumption here that discourse using selective scientific terminology is the only valid way to describe and explain phenomena. Hence primary school teachers must focus on developing scientific language, so guiding children into specific types of dialogue. Indeed studies have shown that teachers' discourse in primary science classrooms is largely confined to developing vocabulary and using it to describe phenomena and processes (Newton and Newton, 2000)

Such an approach though can lead to the situations observed by Dykstra et al (1992)

Very often I have seen students praised for thinking like a scientist when it is clear that the students are simply making noises which sound scientific. (P.615)

In contrast a number of researchers have proposed that there should be a focus on development of concepts in pupils' own social language so that they can engage in the dialogic process without constraint and loss of identity. (Hynd et al, 1994; Brown, 2006). Brown and Ryoo (2008) developed studies built around a theoretical framework proposing that complex terminology limits pupils' learning and that use of vernacular language may be more productive. Their work saw some learning gains, attributed to a reduction in disengagement and inferiority, when concepts were introduced using everyday language only. However the study was a small scale quantitative one, focusing on second language learners, and had its limitations.

This study sought to investigate the above approaches in the primary science classroom, which has the advantage of being a setting that has a more explicit focus on literacy, but is an under-investigated one in terms of research. A small scale study that focused on the conceptual development of pupils in their own social language before bringing in the social language of science would seek to address the research objective: How does an approach that separates language and conceptual aspects of science teaching influence the discourse and learning of primary school age children from socially disadvantaged communities?

METHODOLOGY OF THE RESEARCH: DATA COLLECTION AND ANALYSIS

This study employed ethnographic approaches (Denzin, 1997) as it sought to explore concept and language development within primary science classrooms. As part of a project funded by the Graduate School of Education at the University of Bristol three schools were selected to participate. They all served disadvantaged communities in the same geographical area, as evidenced by a range of socio-economic indicators, and also had a high proportion of pupils with special educational needs. In two of the schools head teachers volunteered teachers of Year 3-5 children (ages 8-10) through a consultative process, based on a project summary that I had provided. While in the third I was asked to meet with a group of potential teachers to outline the project and then decide who would carry the work forward.

Data Collection

The two primary data sources were teacher interviews and classroom observation records. The former were semi-structured in nature to enable an exploration of teachers' perspectives on language and science. This part of the data collection also included recordings of the joint planning meetings held with teachers.

Brown and Ryoo (2008) established a planning approach that had three distinct phases: 1) a content construction phase, 2) an explicit language phase, and (3) the introduction of the explicit language phase. The first two phases were developed here in the planning meetings, where forthcoming science topics were deconstructed in terms of their linguistic and conceptual facets. This process determined what science content was to be taught, the scientific terminology associated with the content and teaching approaches that delayed the use of that language. For example, in the topic of plant reproduction, thought was given to how plant parts and processes might be described in everyday language, e.g. the stigma being conceptualised as a "pollen catcher". The third phase, where scientific language was introduced, was left to teachers to determine as they trialled strategies in classrooms over a period of four months.

In two of the schools teachers felt it would be easier to carry out an experimental type study where parallel year groups were assigned to either a) the treatment where concepts were taught using everyday language, and scientific terminology was only introduced at the end, or, b) the control group where concepts were taught using everyday and scientific language. Acknowledging participants' experiences and views can be an important part of the constructivist paradigm (Cresswell, 2008), and so this approach was adopted, though no quantitative testing was carried out.

As insights into the constructivist oral discourse of the classroom were sought, classroom observation was unsystematic and broad in nature, so assisting in gaining perspectives on classroom culture and dialogical interaction. Initial observations were carried out to gauge the baseline of scientific discourse and so enable assessment of any changes in the quality of children's talk.

Data Analysis

Interview data was subject to analysis that examined teacher attitudes and perspectives in relation to affiliation with vernacular or scientific language.

Qualitative analysis of teacher-pupil and pupil-pupil discourse was carried out to gauge levels of exploratory talk, based on methods developed by Mercer(1995). Exploratory talk is a way of using language to construct knowledge and makes collaborative reasoning explicit. In line with Mercer's analysis the quality of exploratory discourse was achieved through monitoring of key linguistic terms such as "because", "I think" or "I agree".

The other means used to analyse the constructivist nature of discourse was framed around the notion of cohesion in classroom dialogue, and the preponderance of anaphoric and exophoric cohesion. Discourse that promotes cohesion with the preceding “text” is classified as anaphoric (Hassan, 2000) while narrative that links to contexts outside the “text” are defined as exophoric. Anaphoric cohesion tends to be a feature of elaborated codes, including scientific discourse, where narrative tends to be decontextualized and mediated by formal, symbolic concepts. Recordings of classroom discourse were therefore transcribed and subject to analysis of their degree of cohesion and whether it was exophoric or anaphoric.

FINDINGS AND DISCUSSION

Teachers’ Perspectives

Even at the initial planning stage a comment such as the following revealed the uncertainty that some teaching staff felt in adopting an approach that limited the use of scientific vocabulary.

I like the idea but don’t really feel comfortable with a novel approach. I think children like getting to grips with the key words, though they don’t always really get their meaning. It makes you feel that they are making progress if they know the words.
Year 3 teacher (School B)

Baseline observations showed that there was an orientation towards literacy activities within the classrooms that predicated the introduction of scientific discourse. While time was given for eliciting pupils’ ideas in their own social language, the transition to introducing new concepts frequently saw an influx of technical terms. The following comment illustrated something of the rationale for this:

I find it quite easy to discuss what children know already, but towards the end of a topic, when you’re trying to bring in the new ideas, it would feel a bit empty not using the key words. Year 4 teacher (School A)

This perhaps revealed the identity issue that primary school teachers, often non-specialists, can have when teaching science. Gee (2001) refers to the invoking of language as a means of conveying identity and it was clear here that the removal of scientific terminology may have exacerbated identity conflict as teachers struggled with their role as a science teacher. There was confusion over how the approaches might be applied to other topics and evidence that teachers’ own affiliation with science was draped around the key words that they were trying to avoid.

The approach that separated the conceptual and language dimensions worked most effectively when teachers focused on observational experience and carefully guided children towards the more abstract ideas. With no assumption of knowledge of technical terms or introduction of new words, children were able to develop understanding in their own social language. While ideas expressed were not always a

complete scientific description, e.g. “*The tube helps to put the man seed down to the ovary*”, there was a sense in the case of work on plant reproduction that pupils had grasped the key processes. An improved ability to articulate concepts and show understanding using everyday and scientific language was a key feature of the Brown and Ryoo study (2008). Several teachers were more positive in their attitudes to both vernacular and scientific language, having a clearer perception of their place and role. One teacher did not even explicitly introduce scientific language as they felt it to be more important that children carried forward an understanding of the concepts. This consideration of the place of language in the science classroom resonated with the need identified by Yore et al (2004) for planned literacy activity to be at the centre of science teaching, rather than peripheral to concept development.

All the teachers reported that the work had motivated less able learners, particularly boys with weak literacy skills. An increased focus on discussion in the classroom was evident, with one Year 5 teacher commenting:

I think it's changed my teaching approach as I've focused more on explanations and discussion. There's been better engagement, particularly by those with weak literacy. (School C)

The same teacher added though:

I think some of the more able girls might be frustrated as they want to know the words. However I do feel they made progress and that they can use the ideas of forces.

Where the approach was carried out with one of two parallel groups teachers showed a tendency to volunteer comparisons as the following comment reveals.

Initially I was quite worried as it felt quite different as I wanted to use the key words, but then soon got used to it. I've then found that we've been going at a quicker pace (compared to the parallel group) as we've been less concerned about vocabulary. Year 3/4 teacher (School C)

While this highlighted some benefits the remark of another teacher showed that children perhaps questioned whether they were missing out on something by not using scientific words and that their learning might be devalued.

One issue is that there has been some cross-over with the other group – a few pupils keep asking me what words (scientific) mean. Year 4 teacher (School B)

Classroom Discourse

The groups which delayed use of scientific terminology or did not use it at all tended to display certain commonalities in their discourse. The narrative tended to be more cohesive with exophoric ties being particularly evident. Table 1 exemplifies talk in relation to the topic of forces and the teacher uses exophoric linkage to help pupils

relate concepts to visual contexts such as a plane and a tennis racquet. Praise is also given when pupils place themselves in the exophoric context, e.g. “you’re like hitting it”. These observations are consistent with those noted in Harris and Williams (2007) where cohesion was important in helping children to make sense of questions and develop a scientific view of phenomena. The anaphoric linking of children’s responses to previous utterances by other children and the teacher also encourages meaning making, which while not resulting in fully formed scientific conceptions does help children of a young age to develop partial explanations of quite complex phenomena. Harris and Williams state the importance of making anaphoric link to scientific language, but here progress has been through linkage to concepts expressed in everyday language, e.g. a child later in the lesson attempts an explanation for the tennis racquet phenomena, “the force push (anaphoric link) when the racquet pushes downwards.”

Where scientific terminology was explicitly used by the teacher narrative cohesion was often more of a struggle, as illustrated by the discourse in Table 2 which again related to forces. The initial open question, “if something’s got lots of air resistance, what might happen to it”, strives for anaphoric cohesion, but appears beyond the children, and results in muddled responses and uncertainty. Attempts to use scientific terminology by the teacher also perhaps reveal conceptual confusion on their part as air resistance is not something that is possessive.

The data in Table 1 also highlights the presence of the characteristics of exploratory talk, “I think, so, because”, and a willingness to offer tentative explanations. In classrooms where scientific terminology was employed children seemed less willing to engage in scientific reasoning and hypothesising, possibly through concern over being verbally correct. The discourse in Table 2 has the example of a child whispering in slightly embarrassed terms the word “friction” without any reasoning attached.

The above features did not show any school specificity, but were associated with teachers who had volunteered not to use scientific terminology, and saw guidance of children’s discourse as central to the learning of science, referred to by Scott and Mortimer (2000) as controlling the “flow of discourse”. Removal of concerns over precise language use may have given them the confidence to promote language as a tool for reasoning, something that Mercer *et al.* (1999) extrapolate to raised levels of achievement.

Table 1: School B. Year 5 class – a group that hadn't used scientific terminology

Speaker	Transcription	Analysis
Teacher	What's happening to the plane? Pause. Pupil A?	Exophoric link
Pupil A	The plane is like producing forces like the air.	Exophoric link, though use of "forces" may be anaphoric. Claim made, no reason.
Teacher	And....	Possibly hints at anaphoric link
Pupil A	The air is pushing it and the force is pushing it through the air.	Reiterates the claim
Teacher	What's happening with the tennis racquet?	Exophoric link
Pupil A	Well you're like hitting it and forcing it to go in the direction you've hit it.	"You're" – exophoric
Teacher	That's alright. Well done A, you've given us quite a good start. B?	Implication that questions might remain unanswered
Pupil B	Um... the airplane and the tennis ball, it's the same force. The bottle is... I think hot air is trapped inside it and so the bottle	"I think", "so" – features of exploratory talk
Teacher	How does it move?	
Pupil B	By the air pushing it maybe?	Anaphoric response. Speculative answer
Teacher	(Shows approval for the idea by intake of breath) C?	
Pupil C	I thought that the water can't get in to make it sink because it's got stuff trapped inside and so it can't get in.	High level of exploratory talk – "I thought, because, so...."

Table 2: School A – Year 4 class. Scientific terminology was used throughout the forces topic.

Speaker	Transcription	Analysis
Teacher	If something's got lots of air resistance what might happen to it? Pupil X?	Anaphoric link of air resistance with action.
Pupil X	It can stick to something.	Responds to teacher, but muddled link.
Teacher	Stick to something, what do you mean by that?	
Pupil X	Like its stuck..... friction (<i>whispered</i>)	Short statements where reasons are not explicit
Teacher	I think you're thinking about friction. It doesn't stick things, it's a force between two surfaces. High friction is when it's hard to move things, low is when it's easy to move. Do you think that with air resistance it's going to be high or low?	The interchange is more "disputational" as assertions are made with few reasons. Anaphoric link attempted between "high/low" in relation to the two force types

CONCLUSIONS AND IMPLICATIONS

The study has shown some benefits in limiting the use of scientific language, in terms of discourse and learning in the science classrooms of primary schools serving socially disadvantaged communities. An increased focus on exploratory discourse and reasoning was seen with some evidence of enhanced confidence in explaining concepts using everyday language and possibly scientific language. Removal of the requirement for verbal precision enabled cohesion in the classroom narrative and contextualised talk that reduced the gap between the scientific way of explaining phenomena and children's owned understanding (Hasan, 2000). Engagement with anaphorically cohesive discourse involves a loss of power which may invoke identity crises for children using restricted codes (Bernstein, 1990). Teachers' confidence in guiding classroom discourse and employing exophoric links showed itself in part to be associated with minimal use of scientific language and increased exploration of concepts. The most skilful teachers seemed to be able to "neutralise" social status by enabling pupils to participate with them in science narrative that focused on concepts, rather than language. Particular impact was noted with certain groups of pupils; the less able and those with literacy difficulties, influenced by incorporating children's social language practice into the discourse of the science classroom, reducing identity conflict.

The planning stage was critical and enabled teachers to see more clearly the difficulties, misconceptions, language issues, and conceptual problems encountered by children. Participant teachers adjusted to the "content-first" approach, but found it much more problematic as to when and how to introduce scientific terminology. Additionally concerns were expressed as to how assessment might take place without a clearly specified body of language. It was evident as well that weak subject knowledge or lack of confidence in it, and teachers' beliefs about pedagogical practice may exert a significant effect on their efforts to use a socio-constructivist, "content-first" approach.

As with other studies, (e.g. Bianchini and Cavazos, 2007), this work has highlighted the importance of identity with science practices in the classroom. Although shifts were seen in the discourse of both teachers and pupils, to the extent where explanations offered were more scientifically correct, there remained the sense that any identity transition was still in its early stage. Constructivism raises issues of power and identity for both children and teachers, but the results of this exploratory study have shown some potential for tackling these issues.

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